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or new stars—stars which suddenly flash up where previously no stars, or at the best, very faint stars, were known to exist—is that they are due to the rushing of dark or relatively faint stars through invisible nebulae or resisting media. The resulting collisions, in effect a bombardment of the stellar surfaces, seem to generate sufficient heat to convert the surface strata of the stars into incandescent gases and vapors. Spectrographic observations have shown for all recent novae that in the course of a few weeks or months the spectra of the novae are converted into the nebular type. Later the nebular spectra disappear and a certain type of stellar spectrum takes their place. These changes occur rapidly, perhaps because the bombardment effects have been but skin deep.

That planetary nebulae may have resulted in some such way from the collisions of stars and the resisting media seems quite possible. Exactly those stars which are travelling with very high speeds would have the greatest chance to encounter resisting media: and further, the disturbances would be deeper and more permanent the higher the speed of collision. Conversely, if this speculation has a basis in fact, that is, if the planetary nebulae have been formed in this manner, the prevailing high velocities would find a natural explanation.

In securing the difficult long-exposure observations upon which this note is based, I have been greatly assisted by several members of our staff, especially by J. H. Moore, E. S. Haynes, and P. W. Merrill.

PRELIMINARY NOTE ON NEBULAR PROPER MOTIONS

By H. D. Curtis

LICK OBSERVATORY, UNIVERSITY OF CALIFORNIA

Presented to the Academy, October 31, 1914

The great number of nebulae in the sky, their well-known grouping in regions distant from the Milky Way, the spiral structure so frequently occurring, and the question as to the place of these bodies in the evolution of the sidereal universe, all present a series of problems as yet only partially solved.

A knowledge of the proper motions or of any rotational movements which these bodies may have would be of very great value in investigations as to the size and distance of the nebulae, and therefore as to their place in the structure of the visible universe. Owing to the hazy and diffuse character of the great majority of nebulae when observed visually, the visual observations of the past, just as they have proved nearly valueless in giving an adequate conception of the form and structure

of these remarkable objects, so they are also inadequate as records of position for the determination of proper motions and rotations. Trustworthy results can be secured only by the aid of photography.

Sixteen years have now elapsed since Keeler inaugurated his program of nebular photography with the Crossley Reflector of the Lick Observatory; and Keeler's plates, in connection with recent photographs secured with the same instrument, afford a large mass of material for the investigation of nebular motions. Some of the diffuse objects of the Keeler program do not admit of precise measurement; some also of the old plates are rather poor; but when the program of repetition, commenced early in 1914, shall be completed, in 1915, sets of photographs, early and recent, with an average interval of time of about thirteen years, will be available for the determination of the proper motions or internal movements and changes of between 80 and 100 nebulae.

This program is now about one-third complete, as regards the taking of the modern plates, and about one-fourth of the measurements have been made. The work to date comprises most of the larger spirals, such diffuse nebulosities as the Orion and Network nebulae, several planetaries, and several very faint small nebulae.

As the early and late plates of this investigation have been secured with the same instrument, the methods of measurement have been made entirely differential. Five or six symmetrically-placed small stars are selected as a common reference system for all the plates of a given nebula, and the nucleus and numerous knots or condensations are measured in each nebula as available.

Detailed results will be published upon the completion of the program, but from the observations already made we may draw the following general conclusions, which will probably not be seriously modified by the inclusion of more objects:

1. In this average interval of thirteen years it has not been possible to detect any evidence of internal movement, rotatory or otherwise, in the nebulae measured.

2. The derived proper motions are so small that they may well be ascribed very largely to the difficulty and uncertainty of measuring these difficult objects. The largest proper motions found are for the planetary nebulae N. G. C. 6905 and 7009: $0.056''$ and $0.054''$ per year, respectively. Those for the other objects measured will average two or three hundredths of a second of arc per year. As the plates are exposed from two to four hours, and as the nebular condensations are much less sharp than star images, the errors of measurement are manifestly much larger than they would be in the case of short-exposure stellar images.

So far as the program has gone, therefore, all the evidence points to a great distance for these objects. As the spirals are undoubtedly in revolution—any other explanation of the spiral form seems impossible—the failure to find any evidences of rotation would indicate that they must be of enormous actual size, and at enormous distances from us. At a distance of one-thousand light-years, supposing mass conditions to be the same as in our solar system, a nebular structure one minute of arc in apparent distance from its nucleus, or 60 times the distance of Neptune from the Sun, would have a yearly angular movement of only $53''$, or a maximum yearly displacement in a given component with reference to the nucleus of only $0.015''$. A much greater time interval will probably be necessary before nebular rotations can be definitely established by measures of position, unless a nebula abnormally close to us be found.

Wolf and Slipher have reported the observation of rotation in the spiral nebulae Messier 81 and N. G. C. 4594, respectively, by means of the velocity-displacements of lines in the spectra of these bodies. The spectrographic method, here as elsewhere, is independent of the distance or absolute size of the object.

DISCOVERY OF THE NINTH SATELLITE OF JUPITER

By S. B. Nicholson

LICK OBSERVATORY, UNIVERSITY OF CALIFORNIA

Presented to the Academy. October 31, 1914

The Ninth Satellite of Jupiter was discovered on photographs taken with the Crossley Reflector of the Lick Observatory, on July 21 and 22, 1914. The photographs were of two and one-half hours exposure, and were taken to secure observations of the Eighth Satellite. The new satellite is fainter than the Eighth, and is estimated as nineteenth magnitude. The identity of the object as a satellite was established from the observations of July 22, 27, and 31 by Leuschner's *Method of Direct Solution of Orbits of Disturbed Bodies*. The motion is retrograde, and the first estimate of the period places it at about three years. The remaining elements of the orbit resemble those of the Eighth Satellite. Additional observations of the satellite have been secured in August and September. A detailed account of the discovery and observations, and of the investigation of the orbit, will be published in a *Lick Observatory Bulletin*.